A southern VLA-based gravitational lens search

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Abstract. We present a status report on our search for multiple-image QSOs among southern radio sources. Our goal is to identify new lenses for use in studies of cosmology and galaxy structure. To date we have examined 3300 radio sources, identified one probable lens and one probable binary QSO along with about 50 candidates deserving further follow-up.

1. Introduction

We are searching for galaxy-scale gravitational lenses among southern radio sources, with the hope that new lenses will advance theories of galaxy structure (by modeling lens potentials) and cosmology (by measuring lensing rates or differential time-delays). We chose the region $\delta = 0^\circ$ to -40°, because this region is relatively unexplored for lenses (see figure on next page) and well-situated for new southern observatories, and yet is (just) visible to the VLA and VLBA. We exclude the region within 10° of the galactic plane to simplify optical follow-up.

Our strategy is similar to the one adopted previously by CLASS, a successful northern lens search program (see Browne; Myers; Rusin; this volume). To screen large numbers of radio sources, we used the VLA in its A-array to obtain 30-second snapshots at 8.4 GHz of thousands of objects selected from the Parkes-MIT-NRAO (PMN) catalog of southern radio sources.

We selected sources that are flat-spectrum ($\alpha > -0.5$, where $S_\nu \sim \nu^\alpha$), since these sources tend to be core-dominated. This makes mapping easier to automate, and makes cases of lensing easier to recognize. The auxiliary catalogs we used to compute spectral indices were the the Parkes (2.8 GHz), NVSS (1.4 GHz), Molonglo (408 MHz), and Texas (365 MHz) catalogs.

2. Progress

To date we have acquired about 3300 snapshots. There are about 50 objects exhibiting multiple compact components separated by 0.2 to 6.0 arcseconds, which will undergo (as appropriate): multiwavelength VLA imaging (to check if the components have similar spectral indices), VLBA imaging, and direct optical imaging.

Objects that pass these tests are candidates for spectroscopy (to check if the components have similar features and redshifts) and HST imaging (to disen-

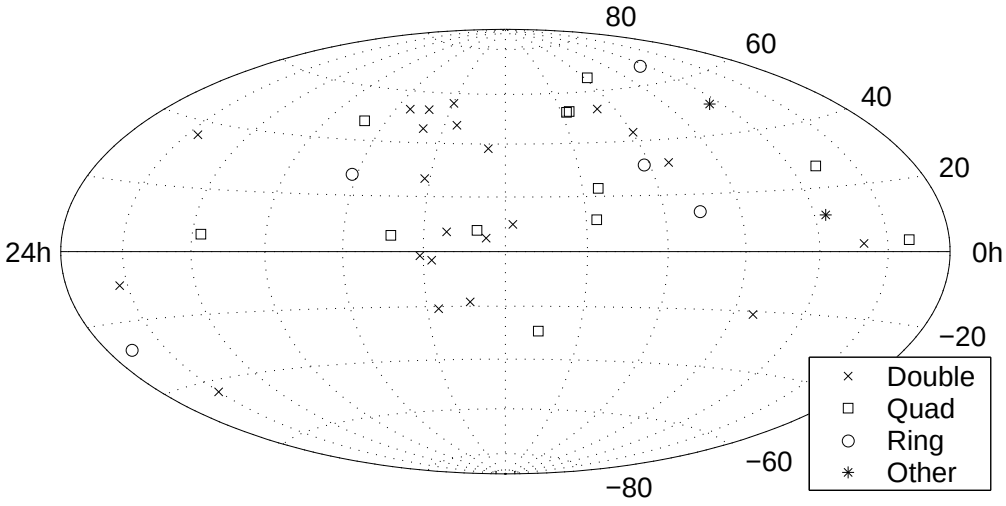

Figure 1. Aitoff plot of well-established cases of multiple-image QSOs, showing the relative scarcity of southern lenses. Data courtesy of CASTLES survey (http://cfa-www.harvard.edu/castles).

tangle the QSO images and the lens galaxy). None of our objects have made it to this final stage yet, although in two cases we have identified objects that are double point-sources in both radio and optical images, with the same separation and orientation. In one of these cases, VLA follow-up revealed that the spectral indices of the components are very similar, indicating a probable lens. In the other case the components have different spectral indices, suggesting a binary QSO. Follow-up with the VLBA is being scheduled.

3. Extending the sample

By combining our observations with the prior observations of A. Patnaik and (separately) A.B. Fletcher & B.F. Burke, we have assembled a nearly-complete sample of about 5000 flat-spectrum radio sources satisfying the criteria:

$$S_{4.8\mathrm{GHz}} \geq 60\mathrm{mJy} \quad \text{for} \quad 0^\circ \geq \delta \geq -30^\circ$$
$$S_{4.8\mathrm{GHz}} \geq 80\mathrm{mJy} \quad \text{for} \quad -30^\circ > \delta \geq -40^\circ$$

Once it has been thoroughly mined for lenses, this sample can be used to measure the lensing rate, thereby constraining the cosmological constant. Based on predicted and empirically measured lensing rates (for example by the similar, northern lens survey CLASS) we expect ultimately to identify 5-10 new lenses.

Acknowledgments. J.N.W. thanks the Fannie and John Hertz foundation for financial support. We also acknowledge the support of NSF grants AST96-17028 and AST96-16866.